# EVALUATION OF THE RISK FOR WORK-RELATED UPPER EXTREMITY MUSCULOSKELETAL SYMPTOMS IN USAF AIR TRAFFIC CONTROLLERS: A PILOT FEASIBILITY STUDY

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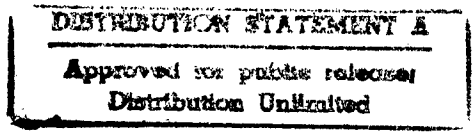


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# EVALUATION OF THE RISK FOR WORK-RELATED UPPER EXTREMITY MUSCULOSKELETAL SYMPTOMS IN USAF AIR TRAFFIC CONTROLLERS: A PILOT FEASIBILITY STUDY

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Work-related upper extremity musculoskeletal disorders (WRUEDs) have been recognized as an increasing industrial problem. Video display terminal (VDT) operators such as data entry and clerical workers have been shown, in many studies, to be at increased risk for these disorders. Only recently have ergonomic considerations received emphasis in designing work stations for the worker rather than for the task. Understanding the risk factors responsible as well as the amount of risk are critical in coping with the problem..

The work of USAF air traffic controllers (ATCs) is in many ways similar to that of the VDT worker but with some notable differences. The ATC job demands great vigilance in attending to radar displays and lacks the excessive repetitive arm, hand and wrist motions often associated with the QWERTY keyboard. This pilot study evaluates the feasibility of a cross-sectional survey of USAF air traffic controllers estimating the prevalence of upper extremity musculoskeletal disorders that are work-related. Prevalence rates were determined using a modified version of questionnaire developed as part of a new USAF program to survey workplaces for ergonomic risk. The surrogate variable for a WRUED was obtained by using criteria of frequency and severity of the musculoskeletal complaints. Physical exams (with the investigator blinded to symptoms),

interviews and medical record reviews were conducted to validate the criteria. ATCs were compared with bioenvironmental, public health and medical technicians having more limited VDT use.

The findings suggest that the study is feasible and the criteria will select a group with symptoms consistent with WRUEDs, similar to those in previous studies. Changes to improve the survey instrument and alternatives in methodology are discussed.

The general belief is that the controllers function in a challenging environment of job stress, reduced lighting, antiquated equipment, poor ergonomic posture and intense concentration while monitoring air traffic on radar screens. If controllers are found to suffer from a higher rate of work-related symptoms, it would encourage further study of their work and ergonomic environment and may lend support to the belief that static postures of low intensity are an important part of these disorders in VDT workers.

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# INTRODUCTION

The relationship between work and painful musculoskeletal disorders was first described over 200 years ago. This relationship has become increasingly important in the past few decades to a point where Repetitive Strain Injuries or Cumulative Trauma Disorders (which will be referred to as work-related upper extremity disorders or WRUEDs) have been called the occupational epidemic of the 1990s (19).

The actual prevalence of WRUEDs in the working population is uncertain, although it is well documented in some specific fields and occupations often labeled as "high-risk" for these illnesses. Only recently have ergonomic considerations received emphasis in designing work stations and tools for the worker rather than the task. Understanding the risk factors responsible as well as the amount of that risk is the first step in reducing the problem.

One group of workers thought to be at increased risk is video display terminal (VDT) workers, common examples being data entry and clerical workers. Attempts to understand the factors that contribute to WRUEDs have received considerable attention due to the increasing numbers of these jobs in the work force, the rapidly rising disability costs to industry and the severe chronic pain in some of these patients (26).

The work of USAF air traffic controllers (ATCs) is in many ways similar to that of typical VDT workers with some notable differences. Their jobs demand vigilance in attending to their radar displays. They differ from many VDT workers in lacking the typically excessive repetitive arm, hand and wrist use associated with the QWERTY keyboard and data entry intensive tasks. They work on equipment designed and manufactured several decades ago, that is fixed in position and does not adjust for individual differences. In addition, they work in low intensity ambient lighting, making other reading tasks difficult and may work on a rapidly rotating shift schedule that may contribute to fatigue.

The purpose of this pilot study is to evaluate the feasibility of a cross sectional study of USAF air traffic controllers to determine whether they are at increased risk of developing work-related upper extremity musculoskeletal symptoms. The goals are to grossly investigate and describe the work and work conditions of the USAF ATC, analyze the feasibility of the planned methods and procedures, and evaluate the initial results of the survey before a decision is made for more extensive data collection. Air traffic controllers would appear to be at risk because of working in a constrained or static posture typical of VDT workers. While they perform various repetitive activities with their upper limbs, it is clearly at rates considerably less than groups, such as data entry operators, known to be at risk. Therefore, ATCs may be expected to have a greater prevalence of neck and shoulder complaints than arm, hand and wrist complaints compared with other VDT workers. The job of the air traffic controller is a unique and important one, and whose work continues to be physically stressful. This study affords a chance to better to understand their ergonomic work environment.

# LITERATURE REVIEW

The terminology used for work-related upper extremity disorders (which have traditionally included the neck) has not always been clear or well defined. Sometimes specific diagnoses, which tend to be anatomically and pathologically based, are applied. Often, only general terms such as, cumulative trauma disorders, repetitive strain injury, repetitive motion disorders, overuse syndromes or occupational cervicobrachial disorders are used. These names seem to suggest a pathological process or etiology, but together illustrate the lack of definitive or objective diagnostic criteria or a full understanding of their relationship with work (14). This lumping and imprecision adds to the confusion, but underscores vital truths. Several different clinical disorders may occur in workers with the same occupational and ergonomic exposures and some of these workers suffer severe pain or symptoms that may not conform to a specifically recognized pattern or "objective" criteria for a diagnosis. These disorders tend to be chronic and it is likely that multiple factors contribute to their development (30).

Highly repetitive or very forceful use of the hands or upper extremity were the first activities to be recognized as important risk factors. Static, restricted or awkward body postures or arm-hand positions (i.e., above the shoulder or used for extended periods), the presence of hand tool vibration (low frequency) and exposure to a cold environment have been identified subsequently (9,17,30). However, personal characteristics (e.g., age and gender), other non-occupational activities, environmental, socioeconomic and cultural factors possibly play a significant role as risk factors for these diseases (30). For carpal tunnel syndrome, body mass index, wrist depth to width ratio and avocational exercise level may be as important as job-related factors (7,11). Recent studies suggest job satisfaction and certain work place stresses may play a role at least in defining the disability of these disorders (1,5,6).

To oversimplify the situation somewhat, these WRUEDs generally are found to affect either the muscle-tendon systems or the peripheral nerves. There have been

indications of another poorly defined group of WRUEDs patients lacking the more classical symptoms of nerve compression syndromes (such as carpal tunnel syndrome) or inflammation of the muscle-tendon unit (11,30,34). However, the difficulties (and different criteria used by researchers) in diagnostically separating them (clinically and objectively), and their multifactorial nature, have only compounded the difficulties in defining, characterizing and studying them and their relation to the work environment (14,20,30,31,).

VDT operators have received disproportionate attention because of 'epidemics' of complaints and increasing disability claims (3,8,10). Various factors seem to be related to the development of musculoskeletal problems including ergonomic, individual and organizational factors (4,5,6,13). Many studies on VDT operators have addressed overwhelmingly female populations, which may be at a higher risk for WRUEDs (15).

A field study, by Hunting et. al., 1981, (21) of 162 VDT and 133 control workplaces, found that constrained postures of VDT data entry workers and typists were associated with musculoskeletal complaints and physical impairments found on physical exam. Factors producing the constrained postures were the distance and height of the keyboards, insufficient space to rest forearms and hands, excessive lateral deviation of the hands operating the keyboard, and a pronounced inclination or turning of the head. Their recommendations suggested a general availability of adjustment for the keyboard, display and chair to provide appropriate positioning, permitting a reduction in the repetitive character of the work and a greater diversity of movement.

Knave et. al., 1985, (23) performed a questionnaire study of subjective symptoms and discomfort among 400 VDT operators (for greater than 5 hours per day) and 150 referents in Sweden. With complaint scores calculated for various regions, significant differences were observed between VDT operators and non-VDT users for the shoulder (for women) and back (for men) regions only. However, the authors

concluded that VDT operators may possibly suffer from more musculoskeletal discomfort in their shoulders, neck and back than do non-VDT users.

Rossignol et. al., 1987, (32) assessed health outcome in 1545 clerical workers (in various industries) by questionnaire. Among the VDT users, the prevalence of musculoskeletal cases (any worker experiencing a condition "almost always" or missed work from it) increased with increasing VDT daily use, up to a 1.8 (95% CI 1.4-2.2) prevalence ratio for those that worked 7 or more hours per day. When stratified by specific complaint, this relationship was shown to hold true for reported neck and shoulder discomfort, while the relationship was not as clear for the reported arm and hand. Some associations between VDT use and regions (for neck, shoulder and low back) were seen for some industries but not for others.

Hagberg and Wegman, 1987, (15) reviewed the literature calculating prevalence rates, odds ratios and their confidence intervals for different occupational groups. Despite the fact that they had to depend only on job titles or brief job descriptions, associations were noted suggesting that highly repetitive shoulder muscle contractions, static contractions, and work at shoulder level are hazardous exposure factors. They hypothesized that the exposure responsible for causing tension neck syndrome was static tension of the neck and shoulder muscles. Keyboard operators (pooled from four occupational groups of keyboard operators and typists) had a standardized (for age) odds ratio of 3.0 for tension neck syndrome with an etiologic fraction of 0.67.

Winkel and Westgaard, 1992, (43) evaluated the scientific evidence in the available literature of the risks for shoulder and neck complaints. They found it was possible to define the relationship between exposure and effect, and they cited several examples. While greater than four hours of VDT exposure per day was associated with a complaint prevalence rate of 50% or more, the rate dropped to around 20-40% with about 2 hours of VDT use per day (Rossingnol et al., 1987). VDT exposure measured in years on the same job has not shown consistent results, but this may be due to a survivor effect or bias. However, Winkel and Westgaard note some examples demonstrating that

this relationship between exposure and complaints may interact with other factors in workstation design, work intensity and technique, rest periods and alternate tasks, and psychosocial and psychological factors to obscure it.

Bergqvist et. al., 1995, (4) investigated a number of individual, ergonomic and organizational factors of presumed importance for the occurrence of musculoskeletal disorders in a group of 260 VDT operators. The cross-sectional study utilized questionnaires, as well as medical and workplace investigations (with ergonomic analysis in forty of these subjects), to perform a multivariate analysis of major factors associated with various upper-body musculoskeletal problems. In musculoskeletal discomforts reported by questionnaire, neck/shoulder discomfort (61.5%) were most prevalent, followed by (lower) back (41.3%) and arm/hand (29.9%); little difference was found between men and women. With the exception of tension neck syndrome (21.8%) and cervical diagnoses (23.4%), the prevalence of specific diagnoses was low (shoulder 11.9% and arm/hand 8.7%) on a physiotherapist's exam. Ergonomic variables identified as important to the development of complaints were static work posture, hand position, use of lower arm support, repeated work movements, elevated keyboard and VDT vertical position.

Most recently Yu et. al., (44) surveyed Hong Kong VDT workers and found similar frequencies of neck, shoulder and back complaints as had previous studies. Using multiple logistic regression techniques after standardizing for age and sex, they noted high and significant odds ratios for the factors of neck inclination at work and keyboard height and neck pain, fixed keyboard and screen height and shoulder pain, and fixed screen distance and repetitive movements with arm pain. They also note many suspected factors that became not significant in the final model after adjusting for confounding factors. For example, VDT working experience, daily VDT hours, bent back at work, and incorrect seat height that did not contribute to neck pain in the final model.

In their recent review of occupational loads as a basis for prevention Westgaard and Winkel, 1996, (42) discuss the contention that neck/shoulder complaints may develop at median muscle loads as low as a few percent. They consider that this force range, below 10% MVC (maximum voluntary contraction,) is the most relevant one for workers performing sedentary or light production work and at which workers are prone to develop cervicobrachial disorders. Waersted and Westgaard, 1996, (40) address a possible mechanism in their study which detected the highest levels of attention-related muscle activity in the frontalis and trapezius muscles. They hypothesize that the pain in the region of the trapezius, known for frequent tender points, trigger points and tenderness to palpation, is due to a subset of low threshold motor units responding to attention-related muscle activity. Having prolonged activity at these very low force levels may be the greatest risk as shown in a longitudinal study where brief interruptions of the EMG activity were associated with less development of trapezius myalgia (39).

Several recent publications have summarized the evidence for work-related musculoskeletal disorders and some have focused on VDT users in particular. Inconsistent results have led to considerable controversy whether the use of VDTs increases the risk of musculoskeletal disorders. Punnett 1995 (29) noted that of the studies she reviewed (that seemed, at most, to have only minor flaws in methodology or weaknesses), 13 of 16 estimated a relative risk of hand or wrist disorders equal to or greater than 2.0. A similar relative risk was noted for neck, shoulder, arm and elbow disorders in 9 of 16 studies. The magnitude of the risk was variously correlated to cumulative years of keyboard work, pace or intensity of workload, and non-neutral posture of keyboard operation.

More to the point, recent articles and editorials have stressed the problems and limitations of the published studies (13,31,37). Laboratory-based human factor studies have short-term outcomes of unknown value in predicting chronic health effects in VDT operators. Poor measurement of exposure and health outcome as well as neglect

of potentially confounding variables (often both age and gender) have been common. The predominance of cross-sectional studies fall prey to distortion due to survival bias and an ill defined temporal sequence between exposure and outcome. Objective measurement of health outcomes has been rare in these studies and usually self-reported symptoms by questionnaire or interview has been used as a surrogate. The relationship between these symptoms and the disabling disorders sometimes seen is unclear as well.

The Nordic Questionnaire, the most frequently used in the past, has been known to have good reliability (24). In the quest to develop a simple screening questionnaire, asking only about the presence of symptoms in the past 12 months and past 7 days, it lacks information to quantify a positive response. The Nordic Questionnaire has been adapted and other questionnaires have been developed, but validity remains a problem. A basic problem is that they have often not asked if the symptoms are work-related. A few recent studies that have looked at this problem and these suggest that questionnaires can give a good indication of the work-related upper extremity disorders (22,27). Others have noted however that when physical examinations are conducted concurrently, often only about half the prevalence rate is observed (17).

Occupational stresses and psychosocial factors have been associated with VDT use and with reporting musculoskeletal discomfort. While the psychosocial factors have been consistently associated with musculoskeletal outcomes, these factors have varied among studies making comparisons of influence difficult (13,14,20).

Recent ergonomic research has been able to specifically characterize some of the motions and forces associated with the repetitive motion symptoms (i.e., 25,28,35). New and unifying theories of cumulative trauma disorders have been suggested, such as the recent one by Higgs and Mackinnon (19), and they may help redirect research and clarify some its conundrums (i.e., the poorly classified patients discussed earlier).

Reasonable advancement in the understanding of these disorders depends on improvements in the studies and their design. However, considering the low relative rate that workers develop the debilitating, severe, chronic forms of these diseases,

opportunities for the prospective studies, that have been called for, seem somewhat limited and expensive. The poorly understood and ill-defined neck and shoulder syndromes have defied objective diagnoses (14,34), and medical provider follow-up and evaluation to make these clinical diagnoses will always be expensive. Improvements in exposure measurement seem more likely to occur as electronic technology of all forms becomes more available.

# MATERIALS AND METHODS

## Study Design

A cross-sectional prevalence study of musculoskeletal symptoms in volunteer USAF enlisted air traffic controllers (exposed) was performed and compared with a group of volunteer USAF enlisted aerospace medicine squadron technicians (unexposed). A questionnaire was used to obtain musculoskeletal symptoms, work-related job risk factors, medical history of work-related or associated illnesses, and work situation or organizational factors. These musculoskeletal symptoms (weighted by severity and frequency), were evaluated for association with reported job-related risk factors. The self reported risks and symptoms were evaluated for consistency with the results of a medical record review and a physical examination and interview. The ergonomic work environment of the ATC in the RAPCON (radar approach control facility) was investigated through interviews with controllers and brief direct observation.

## Population

Volunteer USAF enlisted air traffic controllers and volunteer enlisted technicians from the aerospace medicine squadron from Laughlin Air Force Base composed the exposed and unexposed populations. Laughlin AFB, Del Rio, Texas was chosen because it had the necessary facility (a RAPCON or radar approach control) employing air traffic controllers, and it was the closest such facility to San Antonio. It had only day and swing shifts and not the rapid forward rotating shifts found at many other bases . The study was approved by the Director of Base Medical Services who cleared the study with the Base Commander.

As noted in the introduction, air traffic controllers were chosen for their unique job, requiring vigilance in monitoring to radar displays, but without the excessive repetitive hand and forearm use typical of many VDT users noted in other studies. As the unique work and environment of the air traffic controller might involve other factors which could be of significance, the work situation was briefly investigated. This was done by observation, simple measurements of the workstation and discussions with the supervisors and the air traffic controllers about their duties.

The aerospace medical squadron technicians were chosen as a comparison group for several reasons. First, this researcher was familiar with their jobs, that generally consist of varied work but predominately involving light to moderate clerical and VDT duties. Second, it was hoped that the study's focus on individuals on flying status, and its occupational illness and ergonomic related investigation, would stimulate interest in the groups with responsibilities in these areas enough to influence active participation. Specifically these groups included the Physical Examination, Flight Medicine, Public Health and Bioenvironmental Engineering sections.

Cross-sectional studies suffer from several disadvantages so the population was chosen to optimize results. First, ATCs have an unusual job that is expected to be somewhat standardized and limited in its range ergonomically, thereby limiting exposure variability. Part of this pilot study provides a brief overview of the ATC duties, the work stations and likely exposure problems. While not able to prove a temporal relationship, military medical records are available to review previous symptomatology and injury history before military service and all medical care since. Military medical care is comprehensive and problems that cause significant discomfort or inability to perform routine duties are likely to be reported (especially for eventual disability compensation). This is especially true of the ATCs (the exposed group) being under special duty status. These personnel are required to have all medical complaints or health care visits reviewed by their base flight surgeon. In the USAF, the flight surgeon often functions as the de facto occupational medicine specialist and should be

more aware of such issues. Personnel records of job or duty assignments codes are well controlled and because of military regulations and needs, changing career fields is infrequent. Those leaving the air traffic control specialty in the Air Force are unlikely to be doing so because of musculoskeletal complaints, let alone unreported ones. If the new USAF program survey is used as hoped, data on various work groups will become available for comparison. Last, it is an organization of relatively healthy individuals, who tend to exercise regularly, so complaints because of poor physical condition should not be a concern.

The general criteria for inclusion in the study were the use of those enlisted controllers and technicians who currently worked either, at the RAPCON or in the four Aerospace Medicine sections, were at least 3 months past their basic technical training and were not solely in supervisory positions. All USAF air traffic controllers are on special duty status ("flying status") requiring them to be medically qualified to perform those duties. Consequently, all the 'unexposed' group medical records were screened, during the medical record review, for conditions that would be disqualifying to flying status or not likely to be waived (a process to waive medical regulations and allow clearance for special duty status). Unwaiveable individuals were excluded from the study. Considering the number of waivers given for many minor problems allowing ATC duty, some leniency in the unexposed group for commonly waived problems was allowed.

**A sample size** determination was done to estimate the size needed for the full study. In order to detect a relative risk ratio of 2.5 at an $\alpha$ of 0.05 and a power of 80% with an estimated unexposed group symptom frequency of 10%, the sample size needed for each group would be at least 112 (reference 12, as calculated with Epi Info version 6). The unexposed prevalence value was chosen because previous studies show values in the range of 0-20% for control groups reporting symptoms and 10% was recommended by the USAF Chief Ergonomist from his experience with the USAF questionnaire validation study. The value of 2.5 for the relative risk was chosen because

several studies of VDT operators, usually data entry or directory assistance operators, note values in the range of 3 - 5 (1, 4,15). Of course, larger samples would be needed for the defined statistical significance if the unexposed frequency is lower or the true relative risk ratio is less than 2.5.

**The Survey Instrument**

The survey instrument (Appendix A) was adapted from the USAF Job Requirements and Physical Demands Survey form developed by the USAF Chief Ergonomist and recently approved by Headquarters USAF. It is a quick, effective screening tool, identifying potential sources of exposure to ergonomic risk factors (taken from the scientific literature) and allowing calculation of employee-reported prevalence rates of musculoskeletal complaints for the various work areas found throughout the Air Force. The USAF ergonomic group private contractor for this survey performed testing for usability and reproducibility. Validity testing was performed and overall, the survey showed a significant correlation between a composite score of the job site's worker symptoms and job task factors with an ergonomic evaluation (done by a "gold standard" ergonomist) of risk for work-related disorders (personal communication).

A few additions and changes to the survey were made. One addition asks about the need for corrective lenses. Definitions were added for the responses of daily, weekly and monthly symptoms. Open response areas were added to document symptom characteristics further, and list any significant participation in sports, recreations or hobbies and if these cause any musculoskeletal symptoms.

Identifiers on the survey include age category in years (<20 yr., 21-30 yr. , 31-40 yr. , >40 yr.), gender, rank, length of service for current base, current shop, in the USAF and in that USAF specialty. **Part I** of the survey begins by asking, for each major body

region (shoulder/neck, hand/wrist/arms back/torso, legs/feet and head/eye), about **physical job factors** that are a concern or associated with a risk for musculoskeletal illness. The participants scored these factors based on the amount of time spent per day using a four point scale of never, 0-2 hr., 2-4 hr., or 4-8 hours. Questions 1-7 scored shoulder/neck work tasks, and questions 8-21 hand/wrist/arm tasks, on this four point scale. **Organizational factors** are surveyed in questions 39-44 on a 5-point scale from strongly disagree to strongly agree. These questions relate to job stress (overload, role ambiguity, recognition, job suitability). Questions 45 asked the subject to classify the **overall physical effort** required by tasks performed on a daily basis, and uses a version of the Borg Scale (Borg, 1970). **Discomfort factors** are then listed for each of five body regions. The subjects were first asked, if they experienced, in the past twelve months, "any discomfort, fatigue, numbness, or pain that *relates to your job?"* They were then asked to score frequency (daily, weekly, or monthly) and intensity (mild, moderate, or severe). In **Part II**, questions 61-66 concerned health care issues and somatic reactions to any work-related problems noted. **Part III**, has three questions in an open response format. The subjects documented personal opinions on their most problematic work-related tasks or postures, detailed symptom characteristics of those scored earlier in the survey, and significant sports, recreation or hobby activities that the person has been involved in and if any of those activities have caused any long term or recurrent musculoskeletal symptoms.

**Data Collection**

All participants were informed of the voluntary research project one to two weeks prior its starting. The consent form (Appendix C) was the first page of the survey package. The consent only relayed the survey's interest in work-related musculoskeletal

symptoms and blinded the subjects to the study's particular focus on the neck and upper extremity.

Data collection began with **the administration of the survey**. For the air traffic controllers, it was done just before, during, or just after their work shifts while at the RAPCON. The unexposed group was examined by appointments made at the flight medicine clinic. All subjects were given the survey instrument with minimal instructions, but were told they would be given the opportunity to ask survey-related questions. The entire survey, which covers all the body regions, was used to blind the subjects to the study's specific focus on the neck and upper extremity. A brief physical exam followed immediately afterward (or in a few cases the following day), and it was done before the results of the survey were known to the primary investigator. The patients were asked not to reveal any survey responses until asked after the physical exam. This methodology prevented investigator bias. The sole examiner was not blinded to whether the individual was in the exposed (air traffic controller) group. However, this information was not critical to the analysis (as was whether the participant has significant symptoms that are consistent with being work-related). Afterwards, the survey was reviewed for completeness; queries were made for certain survey responses (those noting greater proportions of work activity) and the results of musculoskeletal discomfort section. If a positive discomfort response was made in any musculoskeletal area patients were asked: 1) to characterize their symptoms, 2) how long they usually lasted and 3) what they attributed the symptoms to. Information that added to what the subject had already written in Part III, question 1 was included and no additional questions or inquiries were made except if the subject mentioned a previous injury that was related to their symptoms. Before concluding the interview, any specific physical examinations in response to the symptoms noted on the survey were performed.

**The physical examination** included whether the eyes and shoulders were level, the range of motion of the shoulder to abduction, cervical flexion, extension and side

bending, Phalen's, Tinel's, and Finkelsteins's tests, grip strength, palpatory tenderness of the sternocleidomastoid, trapezius, levator scapulae, supraspinatus, infraspinatus, rhomboid and scaleneus muscles as well as the arm, elbow, forearm and wrist. A transparent plastic eight-inch compass goniometer with a string plumb bob was used to determine if the eyes were level. The leveling of the shoulders was determined grossly by the positions of the acromions. These metrics were recorded as equal, or either left or right side elevations. Flexion and extension of the cervical region was grossly determined, with flexion being mildly restricted if the chin barely (within one finger's breath) failed to reach the chest and restricted if greater than that. Cervical side bending was measured by centering the goniometer over the spinous process of C7 and tracking the occipital region in both directions with maximal head movement by the subject. Any difference of greater than 5 degrees between the sides was repeated in both directions and the final result taken.

Osteopathic physical examination of both the cervical and iliosacral areas including standing and seated flexion tests, anterior superior iliac spine position, iliac crest heights and sacral positioning were performed to draw attention away from the study's true interest in the neck and upper extremity.

The **medical record review** consisted of determining recent height, weight, date of birth, vision correction, previous work-related musculoskeletal diagnoses, chronic musculoskeletal complaints or recurrent injuries, conditions associated with work-related musculoskeletal injuries and the possibility of qualifying those unexposed who were not on flying status. The chart review assessed history of previous or recurrent musculoskeletal complaints, whether any work-related diagnoses were previously made, any history of chronic conditions associated with musculoskeletal disorders and eyeglass use.

The subject's responses were collected directly on the nine-page job requirements and a physical demands survey (Appendix A), and the investigator's data collection on the medical records review physical exam log sheet (Appendix B). This

information was later entered into a spreadsheet (Microsoft Excel version 7.0a) for tabulation, scoring, and analysis. Additionally, information about the RAPCON's work stations, including, chair and display dimensions and information about the work types and shifts were collected from interviews with the RAPCON Chief Master Sergeant superintendent, the supervisors and the ATCs and by direct observation.

Field notes were kept to record the process of arranging for, and collecting and analyzing the data. From these notes and recollections, specific and general problems, hindrances, and time spent will be discussed in relation to the feasibility of the full study.

## Analysis

The general reliability of the survey instrument was examined by comparing the findings of the medical records review and the interview with the responses for health care, i.e., seeing a provider for work-related musculoskeletal complaints; receiving a

**Table 1 - Weight scores for discomfort complaints and shaded region defined as consistent with a work-related disorder**

| Criteria Table | Mild | Moderate | Severe |
|---|---|---|---|
| Daily | 5 | 7 | 9 |
| Weekly | 3 | 5 | 7 |
| Monthly | 1 | 3 | 5 |

previous work-related musculoskeletal diagnosis; chronic medical problem; requirement for vision correction; and coding of age group.

The primary analysis of the discomfort symptoms was based on questions 46-48 and 49-51 (for shoulder/neck and hand/wrist/arm regions respectively) and the criteria table above (Table 1). The definitions for daily, weekly and monthly are part of the instructions for that page. Daily was defined as 80% or more of the work week (on at least 4 of the 5 work days), weekly as at least one day per work week on average, and monthly as at least every other month on average (at least six days or times per year).

Those with a response in the shaded area (weighted value of 5 or more) were considered to have symptoms consistent with a work-related upper extremity musculoskeletal disorders. This level of symptom frequency and severity was chosen based on the common symptomatic diagnostic criteria of tension neck and cervical

syndromes found in the literature and which would be expected to exclude any less frequent or important complaints (15,16,27). Those with a negative response or, a positive response in the non-shaded area of the table will be considered to be not consistent with a work-related disorder (Table 1). The results were tabulated for both groups as a percentage.

Discomfort symptoms were assigned weighted values as shown in table 1, and asymptomatic subjects were be given a discomfort score of zero. The discomfort score values were compared with the reported job risk factors, age, gender, BMI (body mass index) calculated from the height and weight data, organizational factors and head/neck scores for strength of association (Spearman's rank coefficient of correlation). The job risk factors were weighted to the median value for that category (i.e. none, 0-2, 2-4 and 4-8 hours became 0, 1, 3 and 6 hours) before ranking. Calculations were made using Minitab rel. 11.12.

Evaluation of the reported job risk factors and musculoskeletal complaints of the shoulder/neck and hand/arm/wrist for variability and consistency with medical records and interview results will also be discussed.

# FINDINGS

## Administration

Accomplishment of the study and its survey was generally uncomplicated, probably partly due to this investigator being personally familiar (completely by chance) with the key USAF medical personnel at the base used. This factor may have decreased the time needed for introductions, approvals and initial logistic problems.

No subjects reported difficulty with answering any of the questions. Completing the survey took subjects about 15 to 20 minutes on average depending on their level of involvement and attention. All were properly filled out except for the open response questions of Part III which were either neglected or incomplete for about half of the time. However, having access to subjects at the RAPCON was a problem. Sometimes it was difficult to free people from their ATC positions. This availability depended on the varying demands of the airplane traffic. During the time the study was being conducted, much of the time the traffic was light, partly because the weather was unfavorable for flying.

Physical examination and interviewing took about 17-20 minutes on average for uncomplicated subjects. These were done in a private room on a portable examination table. Those subjects with several areas of discomfort on the questionnaire or with unusual histories of prior injury generally required more time, up to a maximum of 28 minutes. Medical record reviews took approximately 20 minutes per chart on average; many took only 15 minutes for short uncomplicated records. All the medical records were made available and the Flight Medicine staff was very helpful and attentive in scheduling subjects and handling records. The time spent in interviews with the supervisors, observing of the air traffic controllers, measuring and photographing the workstation took approximately an additional 4-5 hours.

Overall, 37 subjects were evaluated, 25 ATC and 12 aerospace medicine squadron members, of which one was eliminated because he was not a full time member of the aeromedical squadron and would not likely be granted a waiver for flying status.

## The Air Traffic Controller Work Environment

The radar approach control (RAPCON) itself is the facility where controlling or directing air traffic takes place. The room where this occurs is known as the IFR room (Figure 1). IFR refers to the instrument flight rules that control the operation of the aircraft (VFR or visual flight rules refer to control by the pilot who is responsible to watch the skies and visually avoid other traffic in the air). The amber radar sweep screens, visible only in the dim lighting of the room, are used to follow the air traffic in the various designated geographic local control areas (for example named west, northeast, east, etc.) for transit through or runway approach and departure.

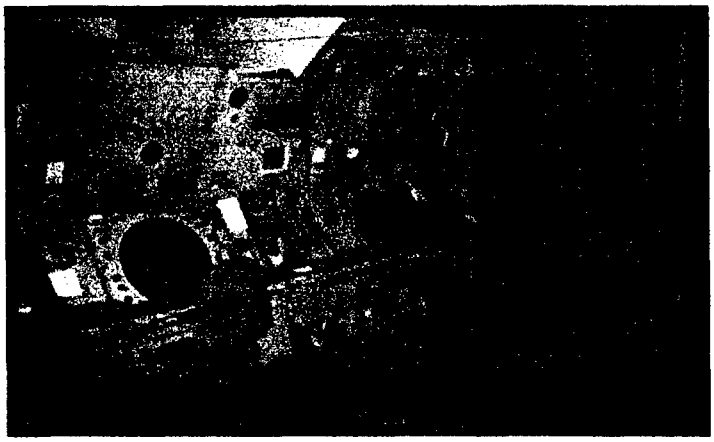


**Figure 1- IFR room in RAPCON**

**Figure 2- Primary scope position**

The three main jobs or positions in the IFR room are the **primary scope position**, the assist position and the coordinator. The primary radar scope position (see fig. 2) involves vigilance of all air traffic within the geographic confines of the assigned area, to maintain safe orderly and expeditious movement of aircraft. The aircraft are in radio contact

with the ATC and the information identifying the aircraft and vital information about its speed, direction and altitude are displayed on the scope next to a cross-hair marker of its position. Part of this information is entered with a special keyboard. Known as the PIDP, which stands for Programmable Indicator Data Processor, (fig. 3, a non-QWERTY keyboard configuration) it is on the level console top by the right hand of the ATC in the primary position. Other important switches are the intercom switches to the left (to the other positions in the IFR room and an overhead ) and above the scope and the preset radio frequencies switches (to speak with the aircraft), low and to the right of the scope.

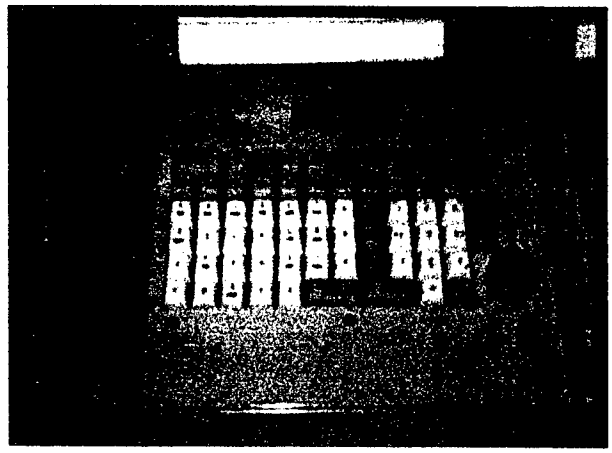


**Figure 3 - PIDP (Programmable Indicator Data Processor)**

Sitting to the right, adjacent to the primary position is the **assist position** (fig. 4). This position is required by the FAA (Federal Aviation Agency). This person works the same area and assists the primary position with contact the aircraft or other scope

**Figure 4 - Assist position**

positions, observing the radar scope, maintaining the routing strips requiring the hand-writing of information (which keep a record of the aircraft and provide information on the control operations performed). These clearance and delivery strips are printed in the IFR room from a direct hook-up from the FAA in Houston. They too have a PDIP but, located in front of their left hand.

The last main position is that of **coordinator** who coordinates activities between the various ATC areas for the transition of aircraft between them as well as monitoring the controllers needing to be fully qualified in the position they are working.

There are two other jobs on a typical work shift. One is the **clearance and delivery position** (fig. 5) in the IFR room. This person collects and organizes the clearance and delivery strips coming from the printer and delivers them to the appropriate scope position. This is considered a rest position (a person is only likely to work this for an hour day, if at all) and a good break from the rigors of the other positions. The last is the **shift supervisor** who manages the shift and does

**Figure 5- Clearance and Delivery position**

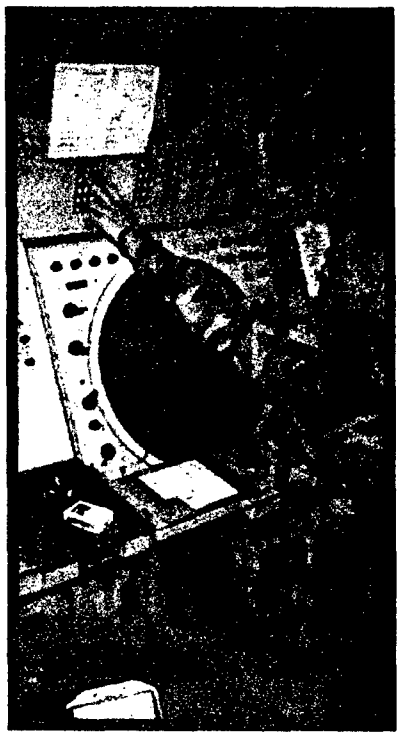


**Figure 6 -Reach left for primary position**

not work any of the positions.

Three very different working postures are involved in the typical ATC duties. The primary scope position maintains vigilant watch on the radar making occasional arm movements to reach and push buttons above the shoulder with their left hand (fig. 6) and sideways reaching motions with their right hand. The PDIP is used to enter aircraft information and may use a centrally placed large track ball to select the aircraft on the scope. All the ATCs have radio switches (a low force required to engage), that are part of the headset, which are generally clipped to their breast pockets but, while in the primary scope position, all the ATCs asked preferred instead the foot switch located by their right foot. The assist position has a right side, angled view of the primary scope and a difficult writing task, either on the narrow desktop or sometimes on the control strips up on a mount at an angle. To some ATCs, there is glare from the scope looking at this angle. The coordinator stands or constantly walks around the IFR room except when monitoring someone on a scope. The coordinator is then hunched over the position if standing or, if seated, beside and slightly behind, leaning around them to observe the information on the scope.

The newest ATCs (arriving as a 3-level or entry level technician from 15 weeks of initial training) need 12-18 months of on the job training before becoming a regular controller (qualified at two primary scope positions and one assist position). They initially spend 1-3 hours per day in the IFR room working mostly a primary, sometimes on an assist position and the rest of their work shift is expected to be spent training on the computer simulators (fig. 7).

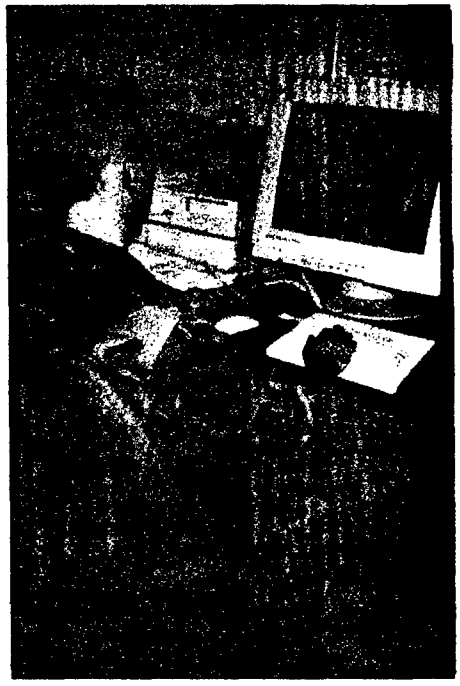


**Figure 7 - Training on simulator**

There are several of these computers with 21-inch color monitors available and they recreate in great detail almost all aspects of the primary position.

Regular controllers (usually 5 and some 7-level or "journeyman" technicians) split half their time between the various primary and assist positions. Most level 7-technicians also function as coordinators and split their total hours in the month equally between the three jobs. However, the higher level technicians are the ones most likely to be the individual on a shift qualified for the more difficult (to master) scope positions. This means that higher level technicians also have more responsibility and are less able to take breaks (not having other similarly qualified people to allow them to be substituted for a break). ATCs may work in position for one to two hours unless there is no one qualified to relieve them or it is too busy. Most seem to get a short break once or twice a day (15-20 minutes) and a lunch break of 30 to 40 minutes.

At this base, crews are divided into two groups of 20-25 persons working either day or swing shifts, five days a week (and with an overlap in the afternoon); each shift lasts about 8 hours. This is to cover the up to eight primary scope positions or areas depending on the amount of traffic. The shifts switch schedules each week and a small crew of 7-8 persons from each group covers one day of the weekend.

**Figure 8 - Primary position side view**


The overall workload of the RAPCON can be judged from the control operations performed and recorded on the clearance and delivery strips is tabulated each day.

In fiscal year 1996, Laughlin ranked tenth of the USAF installations (from the Air Traffic Activity Report) in RAPCON (106,778) and total (RAPCON and Tower) operations. ATCs are usually assigned to either tower or RAPCON duties once they arrive at a base and usually don't switch between them except when changing bases.

The basic workstation layout has been described above. The IFR room equipment is the OD-152 radar and OJ-314 radio systems produced in 1972. The last three figures (fig. 8,9,and 10) show some of the dimensions of the primary scope positions from front and side views and of the assist position. The equipment is all fixed in position and not adjustable. The letter size of the information of aircraft identifiers on the scope is 2 mm high.

The chairs throughout the RAPCON were very comfortable and in excellent condition. They were only nine months old. They were not specifically purchased for the facility but found as excess in the base storage. These were a significant improvement having a large back support and good height and back support adjustment on a stable rolling five-pointed base. They did not have armrests. Taller chairs with footrests have been ordered for use by coordinators performing monitoring functions.

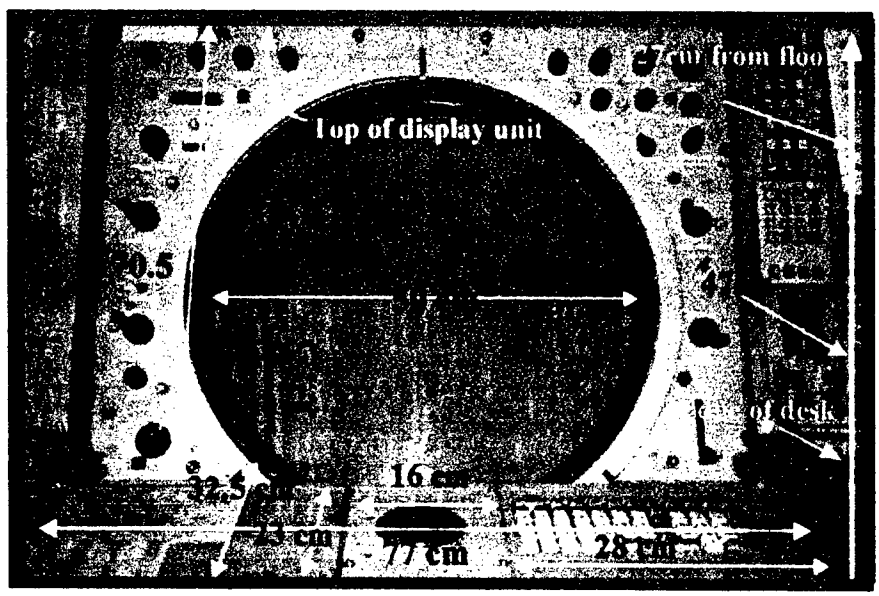
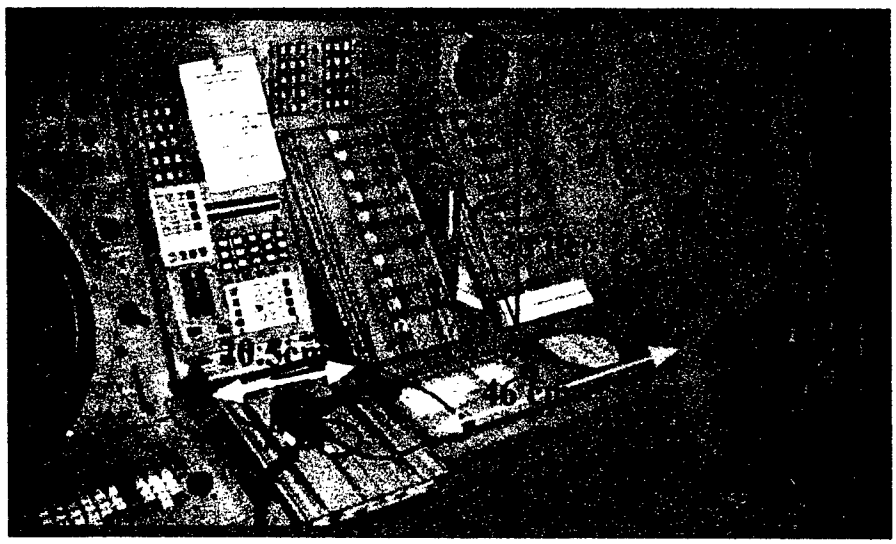



**Figure 9- Front view primary position**

**Figure 9- Assist position with dimensions**



## The Study Sample Groups

Table 2 shows the characteristics of the sample groups. The percentage sampled applies only to the available members of the study groups and does not include the 7 ATCs away on leave, vacation or other assignments or the 3 on leave or changing bases in the aerospace medicine squadron (AMDS). The ATCs sampled were slightly older, of higher rank, included relatively fewer females and had more seniority in the Air Force. This mix is partly due to the small number in the aeromedical group where the higher ranking enlisted filled positions where they functioned in a supervisory capacity only (or believed that they do).

**Table 2 - Comparison of study groups**

| | Sample n | % sampled | % Female | Yrs in USAF | S.D. | Age | S.D. | Rank | S.D. |
|---|---|---|---|---|---|---|---|---|---|
| ATC | 25 | 75.7% | 28% | 9.23 | 6.01 | 29.40 | 6.67 | 4.64 | 1.08 |
| AMDS | 11 | 68.8% | 36% | 5.66 | 4.32 | 26.36 | 5.33 | 3.91 | 0.94 |

## The Survey Results

Overall, the questions evaluated to ascertain reliability of the responses suggest it to be high. Of the 36 subjects, all appropriately completed questions regarding their age categories, noted their use of corrective lens or glasses (fourteen), and any history of chronic systemic diseases related to musculoskeletal systems (two) as confirmed by medical record review. Overall, the number of subjects who reported health care provider visits for pain and discomfort that they felt were related to their job was low (five). Only one of these did not have an obvious notation in the medical record. On interview this was found to be in reference to seeing a physical therapist for acute pain and spasm from a recurrent back complaint approximately two or three times a year,

which could have been missed on the record review. Of the remaining four, two were for very recent musculoskeletal problems that may or not (more likely) be work-related, but caused pain all the time. The remaining two were related to residual or chronic orthopedic problems which were exacerbated by routine work activities. No diagnoses of work-related musculoskeletal illnesses were found on of the medical records. Generally, sports or exercise related musculoskeletal injuries (which were frequently seen in the medical records) were not confused or included with job related ones, unless the work activity clearly exacerbated the discomfort of some residual problem from these injuries.

When reviewing the answers on the job factors with responses of 2-4 or 4-8 hours, confusion occurred for three questions in particular. The first dealt with the wrists being bent to an extreme angle while working. This confusion occurred despite small illustrations of these extremes on the page (and referred to by that question) to avoid misunderstanding. Some assumed that, because they typed, they automatically had their hands in these risky positions. After clarification, almost all felt the need to correct their answers.

The second concerned repeatedly bending the back in the course of work. Many of the subjects referred to and repeated his/her answer of two questions earlier, which pertained to leaning forward continually. In pointing out the difference between the two, again they generally felt their previous response was not appropriate.

The third question referred to using a strong grip with tool or work object, as if tightly holding a pencil. Many subjects responded positively yet, when questioned, thought the question referred to holding a pencil or pen and denied gripping their writing utensil or any work object tightly.

There also were differences in the way that subjects responded leading to overestimation of the amount of time spent in some activities. For example, regarding intermittent typing on the PIDP throughout a work day, some ATCs responded to the repetitive movements question with the 4-8 hour response rather than the cumulative 0-

2 hour answer of other ATCs for the same activity. Because it was not a misunderstanding but a difference in interpretation, these responses were not corrected in the course of the interview.

In the discomfort responses, a two subjects responded about complaints that were not work-related or exacerbated by work, but this was corrected during the interview session. In the health response section, some confusion existed to the diagnoses of rheumatoid arthritis because several subjects answered cautiously about other arthritic related conditions.

**Musculoskeletal Discomfort Symptoms**

Table 3 shows the results of the reported musculoskeletal discomfort symptoms. Both the number and percentage are shown for both groups by body region. The right side shows all those with complaints. The left side shows only those who had symptoms with a weighted score of five or more based on the previously discussed criteria table (table 1) and defined to select cases as a surrogate for work-related disorders. No subjects met the criteria as being work-related by reporting monthly severe symptoms for the upper extremity symptoms.

| Discomfort c/w WRD | | | | | Discomfort - Present | | | |
|---|---|---|---|---|---|---|---|---|
| n=25 | ATC | AMDS | n=11 | | n=25 | ATC | AMDS | n=11 |
| Number | Percent | Percent | Number | Region | Number | Percent | Percent | Number |
| 4 | 16% | 18.2% | 2 | Head/Eyes | 9 | 36% | 72.7% | 8 |
| 8 | 32% | 9.1% | 1 | Shoulder/ Neck | 13 | 52% | 54.5% | 6 |
| 2 | 8% | 0% | 0 | Hand/Wrist/Arm | 5 | 20% | 9.1% | 1 |
| 3 | 12% | 18.2% | 2 | Back/Torso | 11 | 44% | 54.5% | 6 |
| 2 | 8% | 45.5% | 5 | Leg/Feet | 4 | 16% | 54.5% | 6 |

**Table 3 - Number and percentage of group with musculoskeletal discomfort by region**

ATCs seem to report higher rates of discomfort and at a level consistent with a WRUED but the sample sizes are small. In reviewing the interview histories, eleven of the thirteen with neck/shoulder complaints specifically attribute them to the neck and of these, nine specifically to heavy workload and stress at work and/or their leaning posture of the primary scope position. However, of those eight consistent with WRUEDs, one was a shoulder complaint consistent with an impingement syndrome,

another a neck complaint with some attributed as being residual from a fall, but both were exacerbated by work activity. Of the remaining six neck complaints, one had a history and exam consistent with chronic cervical syndrome that was exacerbated by work. The rest were consistent with tension neck syndrome like complaints. Of the five hand/wrist/arm complaints three complained of specific postures at the scope position that initiate the pains, one with symptoms suggesting it was due to direct external pressure.

A relatively large number of the aerospace medicine technicians reported neck (none were shoulder) complaints, but of lesser frequency (none daily) and severity than the ATCs. They generally attributed it to extended computer work or paperwork at a desk with either poor posture (some due to problems with desk, chair and keyboard arrangements) or their neck tilted forward.

To evaluate how discomfort in one region may be reported if there is discomfort in another region, Spearman's coefficients of correlation were calculated between the discomfort scores for the three regions for the entire sample. The results were: head/eye and neck/shoulder 0.180, head/eye and hand/wrist/arm -0.003, neck/shoulder and hand/wrist/arm 0.332.

The prevalence rate ratio (as an estimate of relative risk) between the two groups for the neck and shoulder was 3.5. Odds ratios were calculated for the two area of interest. Where the cell value was zero 0.5 was added to each cell to perform the calculation. The odds ratio for ATCs for shoulder and neck complaints consistent with WRUEDs was 4.7 and for the hand, wrist and arm 2.34. None was significant at 0.05 level with this small sample size.

## The Job Factors

Both groups reported job factors occurring in the 2-4 hour and 4-8 hour range suggesting possible risks. The highest job factors for the air traffic controllers, on average and in order, were for items reporting VDT use with vigilance, repetitive upper extremity tasks, working with their hands out in front of the body, head tipped forward

| Job Risk Factors | | | | | | |
|---|---|---|---|---|---|---|
| **Total n=36** | **VDT vigilance** | **repetitive tasks** | **hands in front** | **head forward or back** | **distracted at work** | **lean forward** |
| Head/Eye | 0.480 | -0.109 | 0.301 | 0.324 | -0.089 | 0.128 |
| Neck/Shld | 0.057 | 0.278 | 0.079 | 0.348 | 0.049 | 0.328 |
| Hand/arm | 0.097 | 0.261 | 0.277 | 0.379 | -0.045 | 0.423 |
| **ATC n=25** | | | | | | |
| Head/Eye | 0.547 | 0.307 | 0.349 | 0.357 | 0.091 | 0.121 |
| Neck/Shld | -0.022 | 0.4 | 0.030 | 0.111 | 0.094 | 0.287 |
| Hand/arm | 0.167 | 0.215 | 0.325 | 0.4 | -0.159 | 0.4 |
| **AMDS n=11** | | | | | | |
| Head/Eye | 0.473 | 0.367 | -0.047 | 0.320 | -0.156 | 0.335 |
| Neck/Shld | 0.281 | 0.37 | 0.4 | 0.401 | -0.199 | 0.4 |
| Hand/arm | -0.089 | 0.4 | 0.276 | 0.285 | 0.044 | 0.269 |

**Table 4- Spearman's (ranked) coefficient of correlation between weighted discomfort scores and individual responses for most prevalent job factors. Values of 0.4 or greater are shaded.**

or back and being distracted by a busy work environment. For the aerospace medicine technicians the highest were having the hands in front of the body, repetitive upper extremity tasks, the head tipped forward or back and leaning forward. Individually these job factors had a poor correlation with the weighted discomfort scores. Results are shown in table 4 and include the head/eye region for comparison.

Evaluating the entire sample, the highest coefficients were for VDT vigilance and head/eye (0.489), leaning forward for the hand/arm/wrist (0.425) and the head tilted forward or back and the hand/arm/wrist and neck/shoulder (0.379, 0.348). The only strong correlation was for the head tilted forward or back and the neck/shoulder (0.901) and repetitive tasks with the hand/arm/wrist (0.735) in the aeromedical technicians, but it is most likely due to the small sample size and the fact that these were some of the most frequently reported job tasks. Of the ATC sample only, VDT vigilance shows a moderate correlation with head/eye complaints

**The Individual and Organizational Factors**

Spearman's coefficient of correlation was calculated for the variables of gender, rank, age, height, body-mass index, physical activity (scored 0, 1, or 2 before ranking) and use of corrective lenses compared with the weighted discomfort scores. Again, low correlation coefficients were found with the weighted discomfort scores. The highest were for neck/shoulder symptoms with age and rank (0.496 and 0.466 respectively). The same poor correlation was seen with the five organizational factors. The same calculation was done to compare time in career field and for the ATCs for the number of years of working in a RAPCON with the discomfort scores. Here the highest correlation coefficient was for ATCs with years in career field (0.467) while for years in RAPCON was low (0.245). In comparison, rank and age were strongly correlated (0.860) as were height and gender (-0.725 because males were scored as 1 and females as 2 before ranking), and years in career field with rank or age (0.895 and 0.900), as would be expected. Indeed, age is probably a confounder in the correlation for years in career field.

**The Physical Exam and Interview**

The results of the physical examinations were few, which in itself is surprising. Despite many medical histories characteristically consistent with tension neck syndrome or (a few) with cervical disorders, physical findings were infrequent. The one subject with a positive Finkelstein's test had no arm or hand complaints. The one subject with a questionable positive Tinel's, both at the wrist and elbow bilaterally, probably had these due to years of participation in championship level sports. The one mildly positive Phalen's test had tingling in all five fingers and a recent history of neck pain and stiffness suggesting a cervical disc syndrome.

Only five subjects demonstrated significant tenderness on palpation of the muscles and tissues of the neck, shoulder, arm, forearm or wrist. This might be more surprising except that none of those who reported neck/shoulder discomfort on the survey form were currently having the neck pains when they were examined. This inconsistency could be due to the nature of the work as the workload intensity varied. The workload was considered light during the brief period the study was being conducted.

There were those with tenderness of a type being of lesser interest to this study. One was suffering from (being diagnosed and in treatment for) medial epicondylitis, and the other had tenderness related to the Tinel's signs discussed above. The three remaining had mild rhomboid or levator scapulae muscle tenderness that related to their complaints, of which only one was of a level consistent with my symptom criteria of a WRUED. In the remaining fifteen with reported shoulder/neck complaints, the corresponding physical exam was essentially benign in fourteen. The histories taken suggested that two were consistent with cervical syndromes (one displayed some evidence of chronic cervical disease on further examination) and two were related to the exacerbation of a previous injury. The remainder (eleven) were consistent with having neck tension complaints, although one had a history of an injury that

complicates the diagnosis. In most, they were characterized as a mild to moderate pain and aching or tightness, that occurred on a weekly to daily basis, that resolves over several hours to overnight with rest. As mentioned previously, were often temporally associated, by the subjects, with working at a desk using a computer for extended periods or doing paperwork or their usual ATC job, with their head leaning forward, and being stressed or very busy at work. In assigning blame for the problem, ATCs chose long and busy days at the primary scope position and aeromedical technicians, a poor or uncomfortable working posture at the desk or computer.

Spearman's coefficient of rank correlation calculated with the less subjective physical exam findings: of whether the eyes or shoulders were level, cervical flexion or shoulder abduction was restricted, or if there was a large difference in cervical side bending (scored either 0-1, or 0-1-2 before ranking) again showed poor or no correlation with the weighted discomfort factors.

# DISCUSSION

As a pilot study, the intent has been to evaluate the feasibility of performing the full scale cross sectional investigation. The study design, the materials, methods and any projected administrative difficulties are the prime focus of such a task. Considering the nature of work-related musculoskeletal disorders, (being multifactorial and not well understood), it is difficult to control for all factors. An initial cross sectional study would be a reasonable first attempt to evaluate an occupational group and allow observation and description of the work before any ergonomic or detailed clinical study. The RAPCON seemed to provide a work site where it would be possible to evaluate a work environment requiring VDT use, but differed by lacking the intense repetitive motion and force in the upper extremity often associated with WRUEDs from VDT use.

Chance and bias were removed as much as possible, but since it was a voluntary study, the selection of controls was difficult. We might suspect that the unexposed subjects, as volunteers, were healthier compared to the "group" cooperation expected among the air traffic controllers, being the focus of attention. This may increase the difference between the groups. Without random selection, the reliability of the prevalence rate depends on capturing a large percent of the available population. This high capture percentage may be more likely when using military subjects. A time constraint did not allow for the evaluation of more subjects, although more volunteers were available. Participation was good overall. Having only one investigator limited the accuracy of physical findings, and having more examiners would improve it. There is the possibility of a healthy worker effect but, that seems less likely in the military population. Data on the military members of these groups who change their career fields and their reasons for doing so may be available from military personnel files, to help answer this question.

Considering the estimate of at least 112 per group (the needed sample size calculated) in the cross sectional study, some changes are needed. Because the aerospace

medical sections are much smaller than that of the ATCs, either other similar groups must be added to the unexposed, or a greater number of ATCs must be added to compensate. In any case, assuming the collection of approximately 40-50 subjects from each additional base, another five bases requiring at least five weeks of data collection would be needed.

An inexpensive alternative might be anonymous random sampling of the ATCs, accomplished by mail, and then compared with pooled data from available USAF survey results. This could accomplish the size needed but relinquishing the power of having the medical records and physical exams for validating the diagnoses. This small pilot study suggests that the medical records and examinations were not very helpful compared to the histories in suggesting the diagnoses.

Attempting to evaluate the risk of upper extremity musculoskeletal symptoms in one occupational group compared to another, the choice of an unexposed comparison group was partly based on presumed convenience and cooperation. However, parts of the unexposed comparison group may have more similar risks to the exposure group or have different risk factors than was anticipated. Comparison to a very different group or multiple groups may be more helpful and enlightening. There is no sizable group of typists or similar VDT workers together at most USAF bases that could be easily captured and serve as controls. An alternative would be to compare ATCs from the RAPCON with those assigned tower duties. Though much smaller in number, they may be the best comparison group. To compare with a very different group, USAF firefighters might be ideal. Available to participate in a study when not training or fighting a fire, they are unlikely to be involved in extensive VDT or desk work on a regular basis. Comparison data is likely to become available with the adoption of the USAF program this survey (in its original form) is central to.

Adaptation of the current survey to ask more specific questions on the characteristics of the job factors, complaints and any relationship with non-work-related musculoskeletal problems could improve it. More detailed instructions preparing the

subjects may help them retain that focus and avoid confusion or varied interpretations of the job factor questions noted.

The protocol of using subject-reported symptoms as a surrogate for WRUEDs follows that of the Nordic Questionnaire and other inventions used in many other studies (2,4,5,7,15,18,24,21,25) . There is no objective diagnosis for most of the WRUED cases and exhaustive testing can be expensive (14,19). Utilizing the survey with a medical record review and a limited physical exam complies with as much rigor as seems possible and reasonable. The criteria used in this study (as consistent with WRUEDs) restricted symptomatic complaints of subjects by frequency and severity. These subjects had symptoms consistent with those typical of diagnostic criteria found in the literature (15,16,27). The prevalence rates and odds ratios calculated are in line with those found in the literature. Misclassification was an infrequent occurrence and might be improved by restricting those with recent injuries that continue to cause pain. The majority were corrected and they consisted of a few subjects failing to report only work-related complaints. The survey was given with minimal introductory instructions and failures occurred when the subjects did not pay attention to the questions. This can be emphasized in future use of the survey.

The scanty findings of trigger points or tenderness of the trapezius or other neck and shoulder muscles was not expected. This variability may be due to the differences in the data collection, specifically its timing, and the experience of the investigator. The lack of physical findings fails to meet the common criteria used for the diagnosis of tension neck syndrome, the most frequent diagnosis associated with WRUEDs of the neck and shoulder in VDT workers. However, the possibility exists, and may in fact be likely, that if these subjects were examined when they had their complaints they too would demonstrate those characteristic physical findings. That there is a pattern to these syndromes related to the work activity should be expected and has been shown. Veiersted and Westgaard, 1993, (39) in their prospective study of female workers performing light manual labor, showed how the symptoms of trapezius myalgia

decreased over weekends and holidays and slowly increased during the work week. They noted that tenderness on palpation was not a good criteria for patient status in their study because this complaint was reported by so many nonpatients. The opposite was noted in this pilot study. However, it may enforce the notion that rest periods or small interruptions in the chronic activity of these muscles may prevent the development of more severe or continuous symptoms.

The ATCs job was more varied than anticipated but, on interviews, supported the idea that the problem was associated with one specific activity, that being the primary scope position. The failure of the subjects to report these medical complaints to physicians is not unusual. The subjects all had work-related or at least work-exacerbated problems yet, none was enough to stop them form their performing their jobs. Many felt these symptoms are "part of the job". Yet, even without palpatory tenderness, weekly to daily and mild to moderate aching, stiffness and pain that lasts for hours and that does not resolve by adaptation to the job or tasks cannot be dismissed. The stress of a difficult shift in relation to symptoms or EMG was not measured (and may be by information from control strips) but may be worthwhile in future studies.

The relatively low coefficients of correlation were expected from the similarity in their responses to the important job risk questions, and the ranked nonparametric analysis of data points with limited separation. Several questions were incorrectly interpreted and the possibility for overestimating time spent in risk related activities seems likely from the variation in some responses. A larger sample size with the use of a different occupational comparison group or more direct or accurate measures of exposure could easily remedy these inconsistencies.

No direct causal relationship of the factors can be determined with this study design. Data was collected by the self reporting of activities of these workers but, for a better, accurate assessment of their activities, objective and observational methods would be preferred. Such a study may be indicated if ATCs are indeed subject to a greater prevalence of symptoms.

The ATCs function in a limited number of roles that seem to have only one problematic posture (the primary scope position) from this pilot study. This may allow the task variation that keep problems from developing or progressing. There are areas were the ergonomic environment of the ATC can be improved but the unique and expensive equipment in place are likely the crux of this issue. Simple engineering controls or changes may not to be feasible.

# CONCLUSIONS

The results of this pilot study suggest it is feasible to estimate the prevalence and risk of WRUEDs in USAF air traffic controllers using this survey. Overall, experience from the pilot study suggests that the survey can be administered with a brief physical exam and interview quickly and simply. There was good general reliability in the responses. The validity of using the chosen criteria, based on the frequency and severity of symptoms, to select problems consistent with WRUEDs seems very good. However, in this pilot study, the subjects failed to show physical findings consistent with criteria used to diagnosis tension neck syndrome in the literature. This is, however, consistent with the methods used here, because almost all patients were without complaints at the time of examination. Planned changes to clarify several questions and frame the intent of the survey should improve its validity in reporting both the symptoms and estimations of job factors or activities causing risk. The use of data from the USAF program or use of an additional groups or a group with different ergonomic risk profile, i.e., firefighters, may help clarify job factor and symptom relationships.

The results of this pilot study are in line with the prevalence, risk ratio and typical syndromes reported in the literature in groups considered to be at increased risk because of similar ergonomic conditions. A significantly increased risk in this job class may lend support towards the theory that some WRUEDs, especially that of tension neck syndrome, are related to static neck postures of low intensity forces.

The challenging work and environment that ATCs must perform in has not been well studied, and they are in a positions of great responsibility. As the older RAPCON systems are replaced, it will be helpful to understand the ergonomics and functioning of the individuals who must use them.

# APPENDIX A

NUMBER

APPENDIX A

**Job Requirements and Physical Demands Survey**

## JOB REQUIREMENTS AND PHYSICAL DEMANDS SURVEY

| **Job Requirements and Physical Demands Survey** | Date (YYMMDD) | **Workplace Identifier:** | |
|---|---|---|---|
| *(use this space for mechanical imprint)* | | Base | Organization |
| | | Workplace | |
| | | Bldg. No/Location | Room/Area |
| | | AFSC/Job Series | |

| | | | | | |
|---|---|---|---|---|---|
| Gender: | Female ○ | | Male ○ | | |
| Work Group | Civilian ○ | Grade _____ | Military ○ | Rank _____ | |
| Age Category | 20 and under ○ | 21-30 ○ | 31-40 ○ | over 40 ○ | |
| Length of service in the USAF | number of years _____ | | | | |
| Length of service in current AFSC | number of years _____ | | | | |
| Length of service at this base | number of years _____ | | | | |
| Length of time in current shop | number of years _____ | | | | |
| Have you completed this questionnaire before? | Yes ○ | No ○ | | | |

# Part I - Job Factors

This section enables you to describe what is involved in your job. Indicate how long you do this work on approximately a daily basis.

## A. DESCRIPTION OF WORK

SHOULDER / NECK

| | | Never | 0-2 hrs. | 2-4 hrs. | 4-8 hrs. |
|---|---|---|---|---|---|
| 1 | I work with my hands at or above chest level *(Figure A.)* | O | O | O | O |

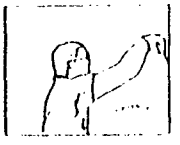


*Figure A.*

| | | | | | |
|---|---|---|---|---|---|
| 2 | To get to or to do my work, I must lay on my back or side and work with my arms up | O | O | O | O |
| 3 | I must hold or carry materials (or large stacks of files) during the course of my work | O | O | O | O |
| 4 | I force or yank components or work objects in order to complete a task | O | O | O | O |
| 5 | I reach or hold my arms in front of or behind my body (e.g., using a keyboard, filing, handling parts, performing inspection tasks, pushing or pulling carts, etc.) *(Figures B.)* | O | O | O | O |

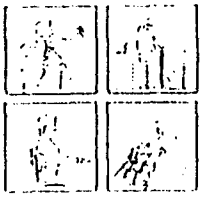


*Figure B.*

| | | | | | |
|---|---|---|---|---|---|
| 6 | My neck is tipped forward or backward when I work *(Figure C)* | O | O | O | O |

*Figure C.*

| | | | | | |
|---|---|---|---|---|---|
| 7 | I cradle a phone or other device between my neck and shoulder *(Figure D.)* | O | O | O | O |

*Figure D.*

# Part I - Job Factors (continued)

HAND/WRIST/ARM

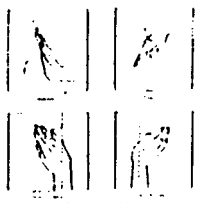


*Figure E*

| | | Never | 0-2 hrs. | 2-4 hrs. | 4-8 hrs. |
|---|---|---|---|---|---|
| 8 | My wrists are bent (up, down, to the thumb or little finger side) while I work *(Figure E)* | O | O | O | O |
| 9 | I apply pressure or hold an item/material/tool (e.g., screw driver, spray gun, mouse, etc.) in my hand for longer than 10 seconds at a time | O | O | O | O |
| 10 | My work requires me to use my hands in a way that is similar to wringing out clothes *(Figure F)* | O | O | O | O |

*Figure F*

| | | | | | |
|---|---|---|---|---|---|
| 11 | I perform a series of repetitive tasks or movements during the normal course of my work (e.g., using a keyboard, tightening fasteners, cutting meat, etc.) | O | O | O | O |
| 12 | The work surface (e.g., desk, bench, etc.) or tool(s) that I use presses into my palm(s), wrist(s), or against the sides of my fingers leaving red marks on or beneath the skin | O | O | O | O |
| 13 | I use my hand/palm like a hammer to do certain aspects of my work | O | O | O | O |
| 14 | My hands and fingers are cold when I work | O | O | O | O |
| 15 | I work at a fast pace to keep up with a machine production quota or performance incentive | O | O | O | O |
| 16 | The tool(s) that I use vibrates and/or jerks my hand(s) and arms(s) | O | O | O | O |
| 17 | My work requires that I repeatedly throw or toss items | O | O | O | O |
| 18 | My work requires me to twist my forearms, such as turning a screwdriver | O | O | O | O |
| 19 | I wear gloves that are bulky, or reduce my ability to grip | O | O | O | O |
| 20 | I squeeze or pinch work objects with a force similar to that which is required to open a lid on a new jar | O | O | O | O |
| 21 | I grip work objects or tools as if I am gripping tightly onto a pencil | O | O | O | O |

# Part I - Job Factors (continued)

## BACK/TORSO

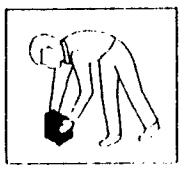


*Figure G.*

| | | Never | 0-2 hrs. | 2-4 hrs. | 4-8 hrs. |
|---|---|---|---|---|---|
| 22 | When I lift, move components, or do other aspects of my work, my hands are lower than my knees *(Figure G.)* | O | O | O | O |
| 23. | I lean forward continually when I work (e.g., when sitting, when standing, when pushing carts, etc.) | O | O | O | O |
| 24 | The personal protective equipment or clothing that I wear limits or restricts my movement | O | O | O | O |
| 25. | I repeatedly bend my back (e.g., forward, backward, to the side, or twist) in the course of my work. | O | O | O | O |
| 26 | When I lift, my body is twisted and/or I lift quickly. *(Figure H.)* | O | O | O | O |

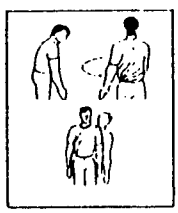


*Figure H.*

| | | | | | |
|---|---|---|---|---|---|
| 27. | I can feel vibration through the surface that I stand on or through my seat | O | O | O | O |
| 28 | I lift and/or carry items with one hand *(Figure I.)* | O | O | O | O |

*Figure I.*

| | | | | | |
|---|---|---|---|---|---|
| 29 | I lift or handle bulky items | O | O | O | O |
| 30 | I lift materials that weigh more than 25 pounds | O | O | O | O |

# Part I - Job Factors (continued)

## LEGS / FEET

*Figure J.*

*Figure K*

| | | Never | 0-2 hrs. | 2-4 hrs. | 4-8 hrs. |
|---|---|---|---|---|---|
| 31 | My work requires that I kneel or squat *(Figure J.)* | O | O | O | O |
| 32 | I must constantly move or apply pressure with one or both feet (e.g. using foot pedals, driving, etc.) | O | O | O | O |
| 33 | When I'm sitting, I cannot rest both feet flat on the floor *(Figure K.)* | O | O | O | O |
| 34 | I stand on hard surfaces | O | O | O | O |

## HEAD / EYES

| | | | | | |
|---|---|---|---|---|---|
| 35 | I can see glare on my computer screen or work surface | O | O | O | O |
| 36 | It is difficult to hear a person on the phone or to concentrate because of other activity, voices, or noise in/near my work area | O | O | O | O |
| 37 | I must look at the monitor screen constantly so that I do not miss important information (radar scope) | O | O | O | O |
| 38 | It is difficult to see what I am working with (monitor, paper, parts, etc.) | O | O | O | O |

# Part I - Job Factors (continued)

## B. ORGANIZATIONAL FACTORS

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 39 I often feel unclear on what the scope and responsibilities of my job are | O | O | O | O | O |
| 40 I often feel that I have too heavy of a workload, one that I could not possibly finish during an ordinary workday | O | O | O | O | O |
| 41 I often feel that I will not be able to satisfy the conflicting demands of various people around me | O | O | O | O | O |
| 42 I often find myself unable to get information needed to carry out my job | O | O | O | O | O |
| 43 I often do not know what my supervisor thinks of me, how he/she evaluates my performance | O | O | O | O | O |
| 44 I often think that the amount of work I have to do interferes with how well it's done | O | O | O | O | O |

## C. PHYSICAL EFFORT

45 How would you describe the physical effort required of your job?

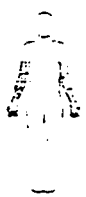
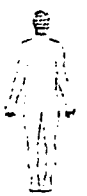
| 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No exertion at all | Extremely light | | Very light | | Light | | Somewhat hard | | Hard | | Very hard | | Extremely hard | Maximal exertion |
| O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |

# Part II - Your Body's Response to Work Demands

## D. DISCOMFORT FACTORS

This section enables you to identify how your body responds to the demands of *your job*. In each section, answer the first question. If the answer is "no" go to the next column. If "yes", please follow the following guidelines for definitions:

Daily occurs nearly every day on average (greater than 80% of the time or 4 out of 5 days). Weekly occurs at least once per work week on average. Monthly is at least once per every other month on average (more than 6 times per year).

| Question |  Shoulder/Neck |  Hands/Wrists/Arms |  Back/Torso |  Legs/Feet |  Head/Eyes |
|---|---|---|---|---|---|
| • In the past 12 months, have you experienced any discomfort, fatigue, numbness, or pain that *relates to your job*? | 46 Yes ○ No ○<br>*If "no", go to question 52* | 49 Yes ○ No ○<br>*If "no", go to question 52* | 52 Yes ○ No ○<br>*If "no", go to question 55* | 55 Yes ○ No ○<br>*If "no", go to question 58* | 58 Yes ○ No ○<br>*If "no", go to question 61* |
| • How often do you experience discomfort, fatigue, numbness, or pain in this region of the body? | 47 Daily ○<br>Weekly ○<br>Monthly ○ | 50 Daily ○<br>Weekly ○<br>Monthly ○ | 53 Daily ○<br>Weekly ○<br>Monthly ○ | 56 Daily ○<br>Weekly ○<br>Monthly ○ | 59 Daily ○<br>Weekly ○<br>Monthly ○ |
| • On average, how severe is the discomfort, fatigue, numbness, or pain in this region of the body? | 48 Mild ○<br>Moderate ○<br>Severe ○ | 51 Mild ○<br>Moderate ○<br>Severe ○ | 54 Mild ○<br>Moderate ○<br>Severe ○ | 57 Mild ○<br>Moderate ○<br>Severe ○ | 60 Mild ○<br>Moderate ○<br>Severe ○ |

# Part II - Your Body's Response to Work Demands (continued)

## E. GENERAL QUESTIONS

61 In the past 12 months, have you seen a health care provider for any pain or discomfort that you think relates to your job? Yes O No O

62 Do you experience any work-related pain or discomfort that does not improve when you are away from work overnight or over the weekend? Yes O No O

63 In the past 12 months, has any work-related pain or discomfort caused you difficulty in carrying out normal activities (e.g., job, hobby, leisure, etc.)? Yes O No O

64 Has a health care provider ever told you that you have any of the following conditions which you think might be related to your work? Circle each that you feel apply to you and put a check mark next to any you currently suffer with pain or discomfort from Yes O No O

- Tendonitis/Tenosynovitis
- Epicondylitis ('Tennis Elbow')
- Thoracic Outlet Syndrome
- Ganglion Cyst
- Bursitis
- Back Strain
- Trigger Finger
- Carpal Tunnel Syndrome
- Knee or Ankle Strain
- Overuse Syndrome

65. Do you have or have you ever had one or more of the following conditions? Circle those that apply Yes O No O

- Wrist Fracture
- Thyroid Disorder
- Rheumatoid Arthritis
- Hypertension
- Diabetes
- Kidney Disorders
- Gout

66 Do you currently need or required to use eyeglasses during or in the performance of your work duties ? Yes O No O

# Part III - Written Responses

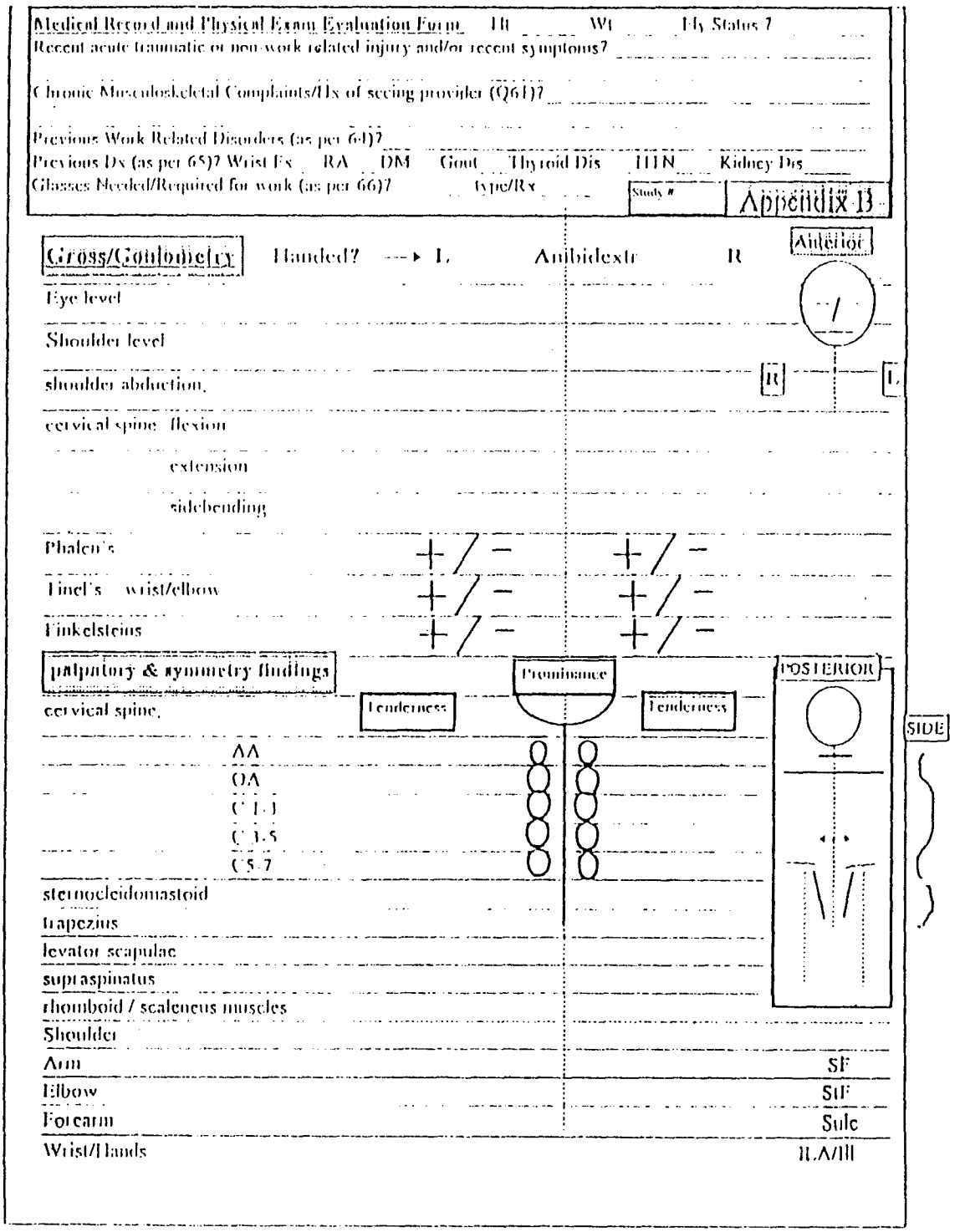
Section 1 requests you to provide details about any pains noted earlier. Section 2 asks about recreation, sports or hobbies. For section 3 think about your job as a whole, including routine, non-routine or seasonal work. Read the questions and describe the activities that you or your co-workers think place the greatest demands on your body.

**1. If you answered yes in any of the questions #46 - 60 about a work related discomfort, fatigue, numbness or pain, please describe your symptoms for each problem region and any other way you can characterize the symptoms (for example: burning, aching, radiating, tingling, or lasted for three weeks or months or resolved by itself or after taking medication or seeing a therapist). Use the back of this sheet if necessary.**

**2. Describe the activities you regularly or seasonally take part in (any regular sport, recreation or hobby). Please describe any long term or recurrent discomfort or pain if one is associated with an activity? (Examples: shoulder pain with softball, bowling, or woodworking, hand pain from bicycling or foot pain from hiking, hand or shoulder pain from home computer use)**

**3. Which tasks are the most awkward or require you to work in the most uncomfortable positions? Are there any tools or pieces of equipment that are notoriously hard to work with? (If so, list them below). If you could make any suggestions that would help you do your job more easily or faster or better, what would you suggest?**

# APPENDIX B


Medical Record and Physical Exam Evaluation Form Ht Wt Hx Status ?
Recent acute traumatic or non-work related injury and/or recent symptoms?
Chronic Musculoskeletal Complaints/Hx of seeing provider (Q61)?
Previous Work Related Disorders (as per 61)?
Previous Dx (as per 65)? Wrist Fx RA DM Gout Thyroid Dis HTN Kidney Dis
Glasses Needed/Required for work (as per 66)? type/Rx
Study #
Appendix B
Gross/Goniometry
Handed? → L Ambidextr R
Anterior
Eye level
Shoulder level
shoulder abduction
R
L
cervical spine flexion
extension
sidebending
Phalen's + / −
Tinel's wrist/elbow + / −
Finkelsteins + / −
palpatory & symmetry findings
Prominence
Tenderness
Tenderness
POSTERIOR
SIDE
cervical spine
AA
OA
C1-3
C3-5
C5-7
sternocleidomastoid
trapezius
levator scapulae
supraspinatus
rhomboid / scaleneus muscles
Shoulder
Arm
Elbow
Forearm
Wrist/Hands
SF
SIF
Sulc
ILA/III

# APPENDIX C

Consent for USAF Subject Participation

TITLE: Evaluation of Work-Related Musculoskeletal Complaints in Air Traffic Controllers

I. INTRODUCTION

I understand that I am being invited by Dr Evan Kapp, MAJ, USAF or his designee, to enroll in a research study because of my occupational field or as part of a comparison group I acknowledge that I have completed my basic technical training more than three months ago My duties are not solely supervisory. I understand this is a voluntary study and as a subject, may refuse to participate or withdraw at any time without penalty.

II. DESCRIPTION

Purpose: It has been explained to me that this is a study of work related musculoskeletal (bone, muscle, joint or tendon) complaints I will be one of approximately two hundred fifty subjects
Procedure: I understand that my participation will consist of completing a questionnaire, undergoing a brief and limited physical examination that at most may involve removal of any over-shirt or blouse but not any undershirt or other garments I will also allow for a review of my medical record to only look at my history of musculoskeletal problems or injuries and to see if I qualify for special duty status It should take about 15 minutes to complete the questionnaire and 15 minutes for the physical examination
Risks or Discomfort: No risks or discomfort is expected
Benefits: No benefits for the individual are anticipated However, some insight into work related musculoskeletal disorders may be anticipated from the research.
Confidentiality: I understand that my name and any other personal identifiers (i e. SS#) will not be used in the conduct of the research or study reports or be placed on the survey questionnaire. I understand that my responses will be kept confidential. On the return of this consent agreement a "secret code", which is a unique number, will be created on this form, the first page of the survey, and a medical record and physical exam log form to allow for accounting and accuracy of the data in the study The consent forms with the secret codes will be kept in a locked file cabinet that will be accessible only to the primary investigator, Dr Evan Kapp I understand that if I have any questions about my participation in this research I can contact Dr Evan Kapp at (210) 662-2702 at any time
Compensation: No direct compensation will be involved in participation in this study

Agreement Statement: By signing this document, I agree to participate as a volunteer in this research study which has been explained to my satisfaction and understanding I understand I can refuse to participate or withdraw at any time I have received a copy of this consent form for my personal file

Signature Soc Sec # Date

Person obtaining consent Date

This study (HSC-SPH-97-024) has been reviewed by the Committee for the Protection of Human Subjects (CPHS) for the University of Texas Houston Health Science Center. For inquiry regarding subject's rights or to report a research-related injury, call the CPHS (713-792-5048)

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# VITA

Evan Zachary Kapp v[redacted], the son of Anne and Calvin Kapp. After graduating Benjamin N. Cardozo High School in 1972 he spent two years at Washington University in St. Louis, Mo. He spent the summer of 1974 taking courses at St. John's University in New York City then went on to complete his Bachelor of Arts degree at the State University of New York at Buffalo in June, 1976 being awarded a Bachelor of Arts with a joint major in Biology and Physical Anthropology. He was employed at Eutectic-Castolin in Flushing, NY until entering the graduate program in Anatomical Sciences at the University of North Carolina At Chapel Hill in September, 1977. He transferred to the State University of New York at Stony Brook and was awarded a Masters in Science in May, 1980. He entered New York College of Osteopathic Medicine at New York Institute of Technology at Old Westbury, NY in 1982 and was awarded his Doctor of Osteopathy degree in May, 1986. He completed his Osteopathic internship at Peninsula Hospital Center in Far Rockaway, NY in May, 1987. He entered the Family Practice Residency at the State University of New York at Brooklyn - Downstate Medical Center in July, 1987 and graduated as, chief resident, in June, 1990. Since that time he has been a proud member of the United States Air Force, previously stationed at Bergstrom Air Force Base, in Austin, TX until May, 1993 and at Yokota Air Base in Tokyo, Japan until July, 1996. He is currently in the Air Force's Residency in Aerospace Medicine at Brooks Air Force Base in San Antonio, TX. In 1989, he married Susan Kempler of Westbury, NY. They have two children Samantha Maxine Kapp, [redacted] Hadden Kapp, [redacted]

[redacted]

This thesis was typed by Evan Z. Kapp.

DEDICATION

To Susan

# EVALUATION OF THE RISK FOR WORK-RELATED UPPER EXTREMITY MUSCULOSKELETAL SYMPTOMS IN USAF AIR TRAFFIC CONTROLLERS: A PILOT FEASIBILITY STUDY

By

EVAN ZACHARY KAPP, BA, MS, DO

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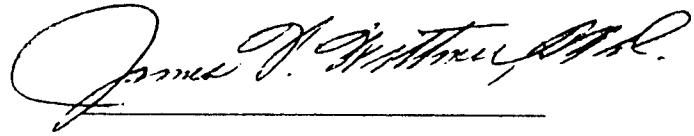
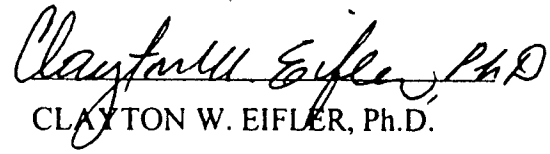


JAMES F. WITTMER, MD, MPH



CLAYTON W. EIFLER, Ph.D.

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